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DIODE

STEP STRESS TESTING PROGRAM

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NAS8-31944

FINAL REPORT
FOR

JANTX1N759A

JANUARY 1979

Prepared
For

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FOREWORD

This is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transistors, diodes, and FETS is to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective will be to gain more knowledge of accelerated stress testing for use in future testing of varieties of discrete devices, as well as to determine which type of stress should be applied to a particular type of device or design.

This report is divided as follows: description of tests, figures, tables, and appendix.

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1.0 INTRODUCTION/SCOPE

DCA Reliability Laboratory, under Contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the voltage regulating diode JANTX1N759A manufactured by Texas Instruments and Siemens.

1.1 Sample Distribution

A total of 48 samples from each manufacturer were submitted to the process outlined in Table I. In addition, two control sample units were maintained for verification of the electrical parametric testing.

2.0 TEST REQUIREMENTS

2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table II after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 high-speed computer-controlled tester. Additional bench testing was also required on the devices.

2.2 Stress Circuit

The test circuit shown in Figure 1 was used to power all of the test devices during the power/temperature stress conditions. The voltage was set by V_Z and the current was varied in order to comply with the specified power rating for this device. Maximum rated power (MRP) was reached on at least one of the test devices. All the

remaining devices were subjected to no less than 90 percent of the MRP for all other devices. See Figure 1 for load resistor values and voltages.

2.3 Group I – Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the power stress process. The diodes were stressed in 500-hour steps at 50, 100, 125, 150 and 175 percent of MRP for a total of 2500 hours or until 50 percent or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table I.

2.4 Group II – Temperature Stress I

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I process. Group II was subjected to a total of 1600 hours of stress at MRP in increments of 160 hours. The temperature was increased in steps of +25°C, commencing at +75°C and terminating at +300°C or until 50 percent or more of the devices failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table I.

2.5 Group III – Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress II process. Group III was subjected to a total of 112 hours of stress at MRP

*Conditions for failure:

A) Open or short
B) Leakage exceeds the MIL limit by 100 times.
C) Other parameters exceed MIL limits by 50 percent or greater.

in increments of 16 hours. The temperature was increased in steps of +25°C, commencing at +150°C and terminating at +300°C or until 50 percent or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table I.

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I – Power Stress

3.1.1 Texas Instruments (TI). The TI sample lot completed the entire 2500-hour Group I testing with no catastrophic failures. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 6.3µA from an initial mean of 46.35nA to a final mean of 6.344µA.

2) The mean value for B_V changed 70.0mV from an initial mean of 12.20V to a final mean of 12.13V.

The control units for this sample lot remained constant throughout the entire Group I testing.

3.1.2 Siemens (SIE). The SIE sample lot completed the entire 2500-hour Group I testing with a total of three catastrophic failures. The first failure occurred 50 hours into the 100 percent MRP step. Serial Number 9064 failed because of excessive I_R leakage. The next failure occurred 10 hours into the 150 percent MRP step. Serial

*Conditions for failure:

A) Open or short
B) Leakage exceeds the MIL limit by 100 times
C) Other parameters exceed MIL limits by 50 percent or greater.

Number 9075 failed the minimum B_V limit. The last failure occurred 500 hours into the 175 percent MRP step. Serial Number 9071 failed because of excessive I_R leakage. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 258.6µA from an initial mean of 2.361nA to a final mean of 258.6µA.

2) The mean value for B_V changed 30.0mV from an initial mean of 12.26V to a final mean of 12.29V.

The control units for this sample lot remained constant throughout the entire Group I testing.

3.1.3 Statistical Summary – Group I. Table IV outlines the test results of Group I – Power Stress process for the two electrical parameters and all measurement points for both TI and SIE.

3.2 Group II – Temperature Stress I

3.2.1 Texas Instruments. The TI sample lot completed the entire 1600-hour Group II testing with a total of 13 catastrophic failures. The first failure occurred 160 hours into the +250°C temperature step. Serial Number 9139 failed because of excessive I_R leakage. The next failures occurred 160 hours into the +275°C temperature step. Serial Numbers 9133, 9136, 9140 and 9143 failed because of excessive I_R leakage. The last failures occurred 160 hours into the +300°C temperature step. Serial Number 9130 failed the maximum B_V limit. Serial Numbers 9129, 9131, 9132, 9137, 9138, 9144 and 9146 failed because of excessive I_R leakage. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 1.942mA from an initial mean of 33.5nA to a final mean of 1.942mA.

2) The mean value for B_V changed 870.0mV from an initial mean of 12.22V to a final mean of 11.35V.

The control units for this sample lot remained constant throughout the entire Group II testing.

3.2.2 Siemens. The SIE sample lot completed a total of 1280 hours before the lot was stopped because the failure rate reached or exceeded 50 percent of the devices. The first failures occurred 160 hours intc the +200°C temperature step. Serial Numbers 9080, 9082 and 9083 failed because of excessive I_R leakage. Serial Number 9077 failed the maximum B_V limit. The next two failures occurred 160 hours into the +225°C temperature step. Serial Numbers 9089 and 9090 failed because of excessive I_R leakage. The last failures occurred 160 hours into the +250°C temperature step. Serial Numbers 9084, 9087, 9091, 9092 and 9093 failed because of excessive I_R leakage. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 3.08mA from an initial mean of 8.17nA to a final mean of 3.08mA.

2) The mean value for B_V changed 20.0mV from an initial mean of 12.23V to a final mean of 12.25V.

The control units for this sample lot remained constant throughout the entire Group II testing.

3.2.3 Statistical Summary – Group II. Table V of this report outlines the results of Group II – Temperature Stress I testing for the two electrical parameters and all of the measurement points pertaining to both TI and SIE.

3.3 Group III – Temperature Stress II

3.3.1 Texas Instruments. The TI sample lot completed the entire 112-hour Group III testing with a total of two catastrophic failures. The two failures occurred 16 hours into the +150°C temperature step. Serial Number 9161 was removed from the testing because of an open-anode-to-cathode junction. Serial Number 9162 was removed from the testing because of a shorted anode-to-cathode junction. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 7.77nA from an initial mean of 94.62nA to a final mean of 86.85nA.

2) The mean value for B_V changed 60.0mV from an initial mean of 12.21V to a final mean of 12.15V.

The control units for this sample lot remained constant throughout the entire Group III testing.

3.3.2 Siemens. The SIE sample lot completed the entire 112-hour Group III testing with a total of six catastrophic failures. The first failure occurred 16 hours into the +225°C temperature step. Serial Number 9104 failed because of excessive I_R leakage. The next failures occurred 16 hours into the +250°C temperature step. Serial Numbers 9094 and 9102 failed because of excessive I_R leakage. The next failure occurred 16 hours into the +275°C temperature step. Serial Number 9095 failed because of excessive I_R leakage. The last failures occurred 16 hours into the +300°C temperature step. Serial Numbers 9100 and 9109 failed because of excessive I_R leakage. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 16.65µA from an initial mean of 1.767nA to a final mean of 16.65µA.

2) The mean value for B_V changed 970.0mV from an initial mean of 12.31V to a final mean of 11.34V.

The control units for this sample lot remained constant throughout the entire Group III testing.

3.3.3 Statistical Summary. Table VI outlines the results of Group III - Temperature Stress II testing for the two electrical parameters and all of the measurement points pertaining to both TI and SIE.

4.0 FINAL DATA SUMMARY

Table VIII summarizes the change in the mean value from the zero hour data to the final data. The graphs of Figures 2 and 3 plot the cumulative percent failures versus the elapsed time for Group II - Temperature Stress I, and Group III - Temperature Stress II. Tables VIII and IX summarize the failures encountered for all three stress groups. The test devices are separated into two groups: Catastrophic failures in Table VIII and parametric failures in Table IX. The data from Table VIII was used as the source for the graphs in Figures 2 through 5.

5.0 CONCLUSIONS

Both sample lots performed well in the Group I - Power Stress testing. TI had no catastrophic failures and SIE had three. All three failures from the SIE sample lot showed damaged junctions resulting from the power stress to which they were subjected. The exact stress at which this occurs is mainly a function of the junction size, the heat sink capability of the die, and the crystal perfection. Failure Analysis points out that

The Group II - Temperature Stress I testing proved to be the most detrimental to both sample lots, and the same failure mode can be clearly seen in the Group III - Temperature Stress II testing. The failure mode in both groups - II and III - seems to be excessive I_R leakage. The Texas Instruments and Siemens diodes failed due to catastrophic junction damage induced by excessive die temperature while under power. It is almost certain that the actual failure mode involded micro-alloying of the metal across the semi-conductor junction. Failure analysis points out that the metal between the internal wire lead and the die on some of the Siemens parts shows evidence of overheating and de-wetting. The dice overhang their mountings on all of the Siemens' devices. Many of the diode samples from Texas Instruments show cracked glass.

A plot showing cumulative failute distribution for Groups II and III was drawn for the Siemens sample lot (Figures 4 and 5), but a complete plot for the Texas Instruments sample lot could not be drawn due to an absence of main failure points in the Group III testing (Figures 2 and 3). Figures 4 and 5 display the data for the Siemens sample lot used to calculate an activation energy of 1.58ev.

A broken circle around a marked point, on the graph, indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated failure point. The regression line was drawn using the least square method.

The activation energy was calculated from the formula:

$$E = \left[\ell n \left(\frac{t_1}{t_2} \right) \right] \left[\frac{8.63 \times 10^{-5} \text{ eV/}^{\circ}\text{K}}{\left(\frac{1}{T_1 + 273} \right) - \left(\frac{1}{T_2 + 273} \right)} \right] \text{eV}$$

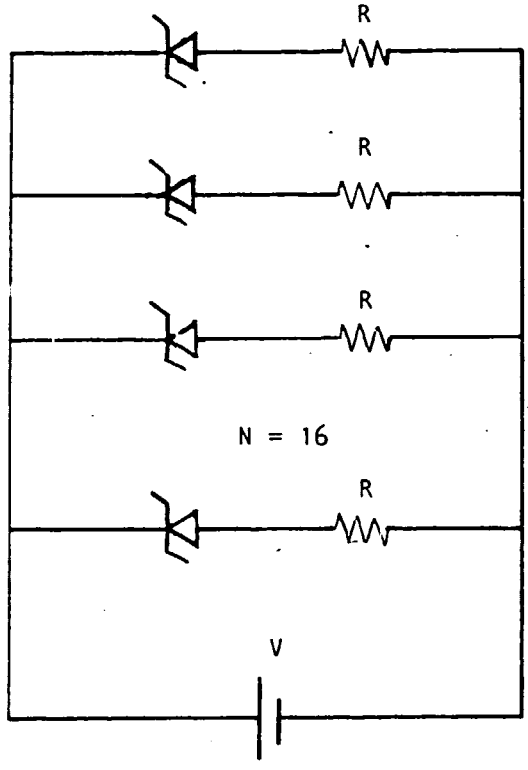
Where: t_1 = step of Group II - Temp Stress I = 160 hrs.

t_2 = step of Group III - Temp Stress II = 16 hrs.

T_1 = temperature in $^{\circ}$C of 16% failure for Group II.

T_2 = temperature in $^{\circ}$C of 16% failure for Group III.

ZENER DIODES



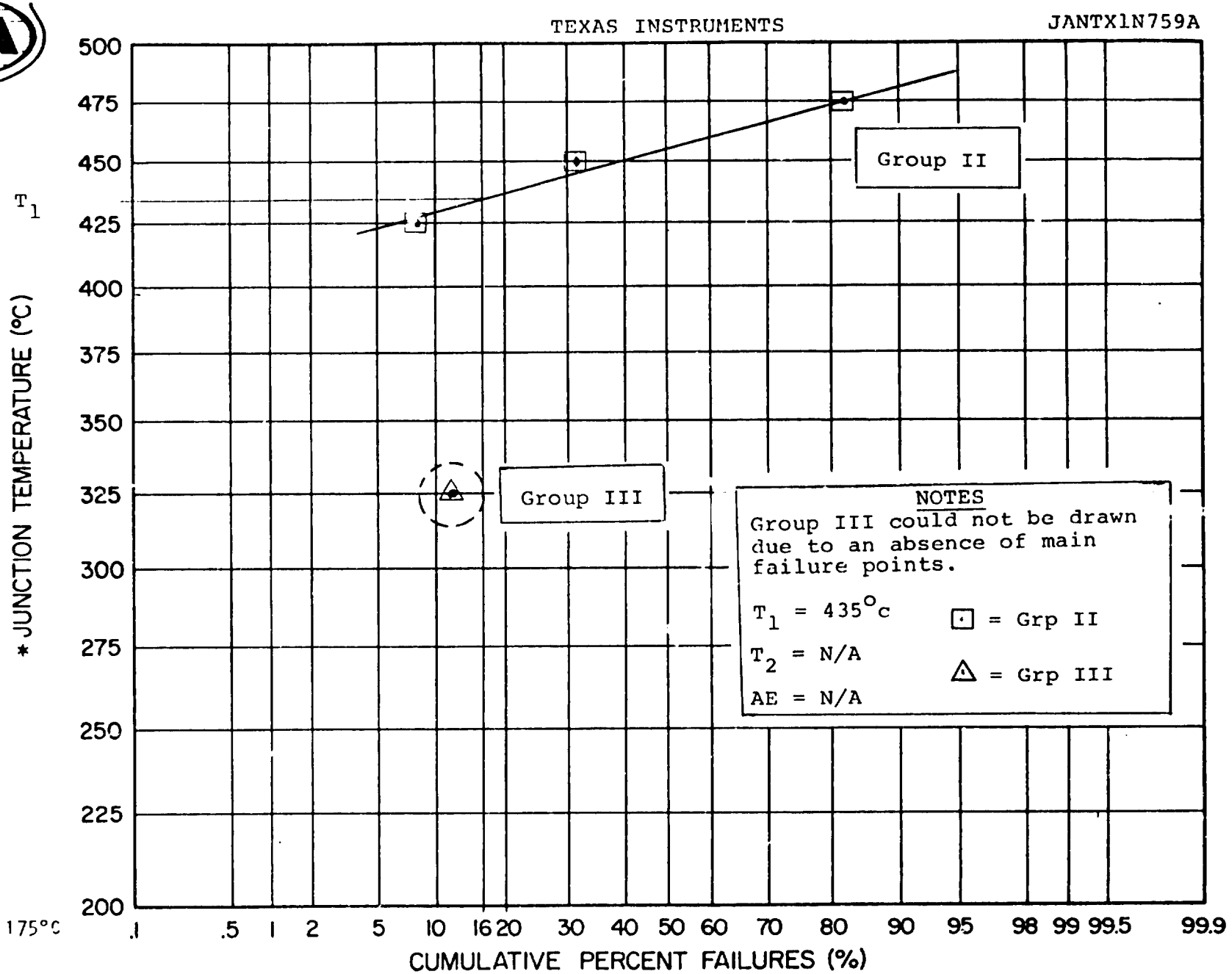
$R = VZ \div 1.75\ IZ_{MAX} \pm 50$ percent

$P_d = VZ^2 \div R$

FIGURE 1
Power and Temperature Stress Circuit
for JANTX1N759A

NOTE
FOR TABLES
4 THROUGH 7

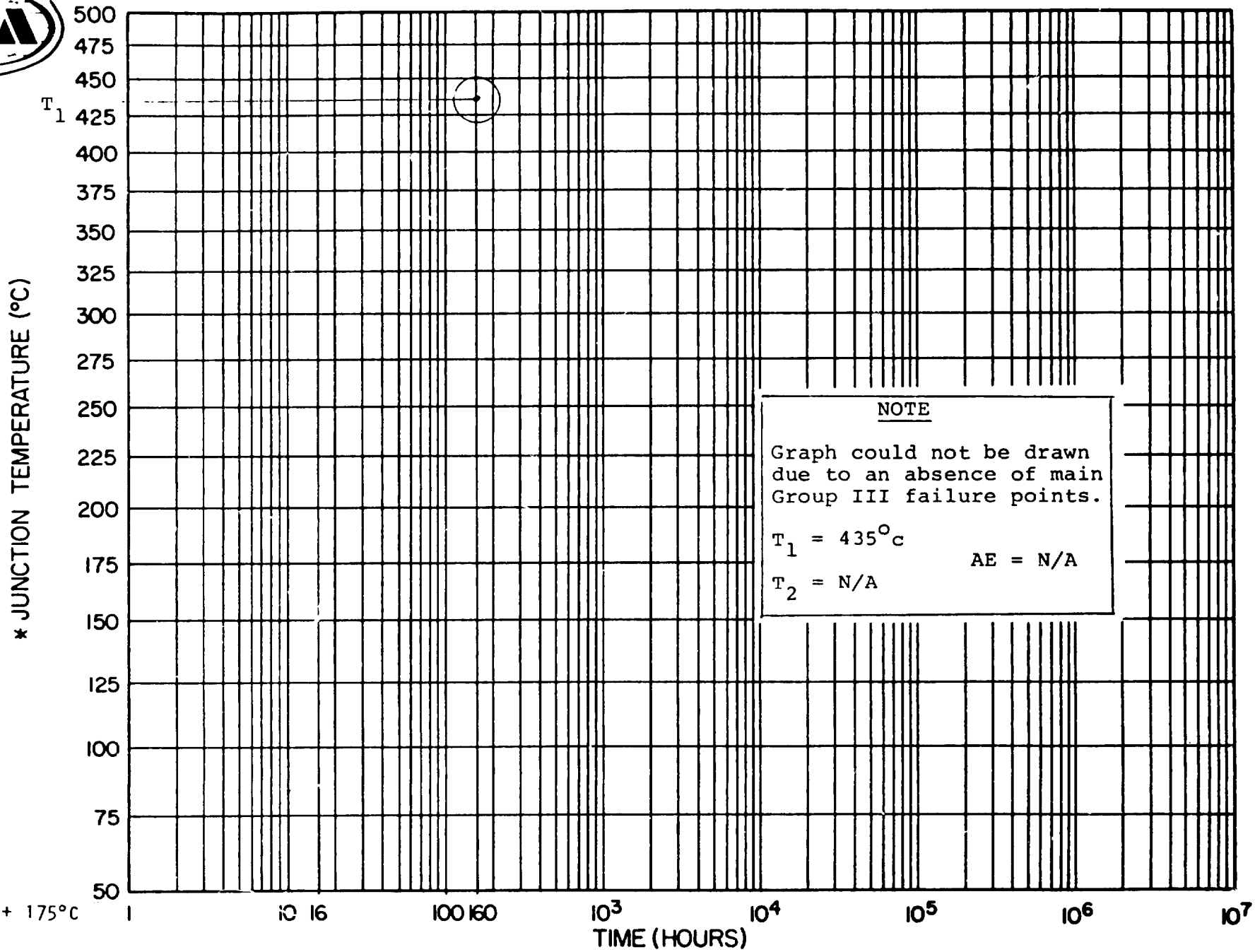
The minimum/maximum initial and final data generally have an absolute accuracy of ±1% of the reading and ± one digit except for readings greater than 9.99mA which have an absolute accuracy of ±2% of the reading and ± one digit. The data also has a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.



*NOTE

$T_J \approx T_A + 175°C$

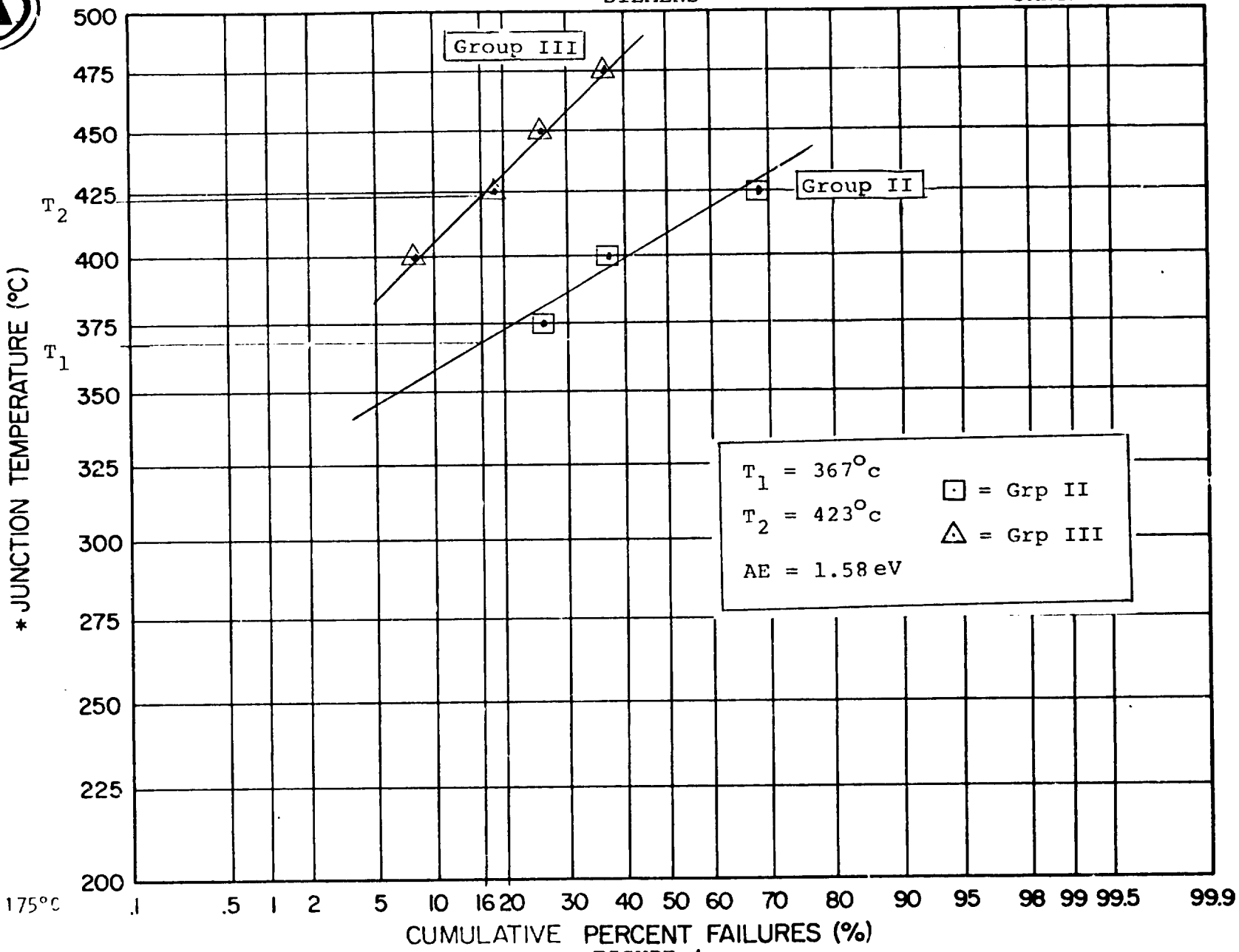
FIGURE 2
Cumulative Percent Failures Versus Junction Temperature, Texas Instruments



*NOTE

$T_J \simeq T_A + 175°C$

FIGURE 3
Time Steps Versus Junction Temperature, Texas Instruments

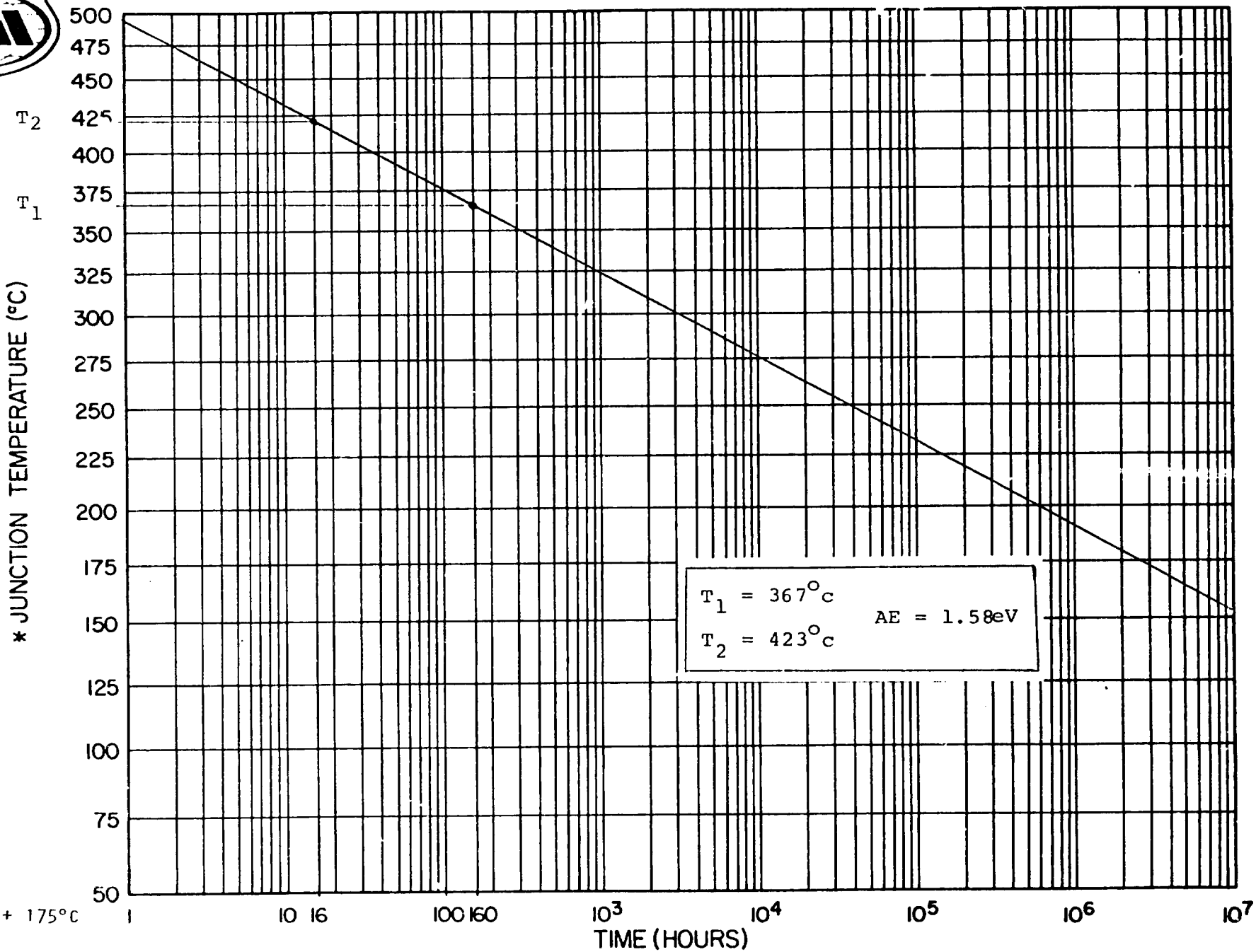


*NOTE

$T_J \approx T_A + 175°C$

FIGURE 4

Cumulative Percent Failures Versus Junction Temperature, Siemens

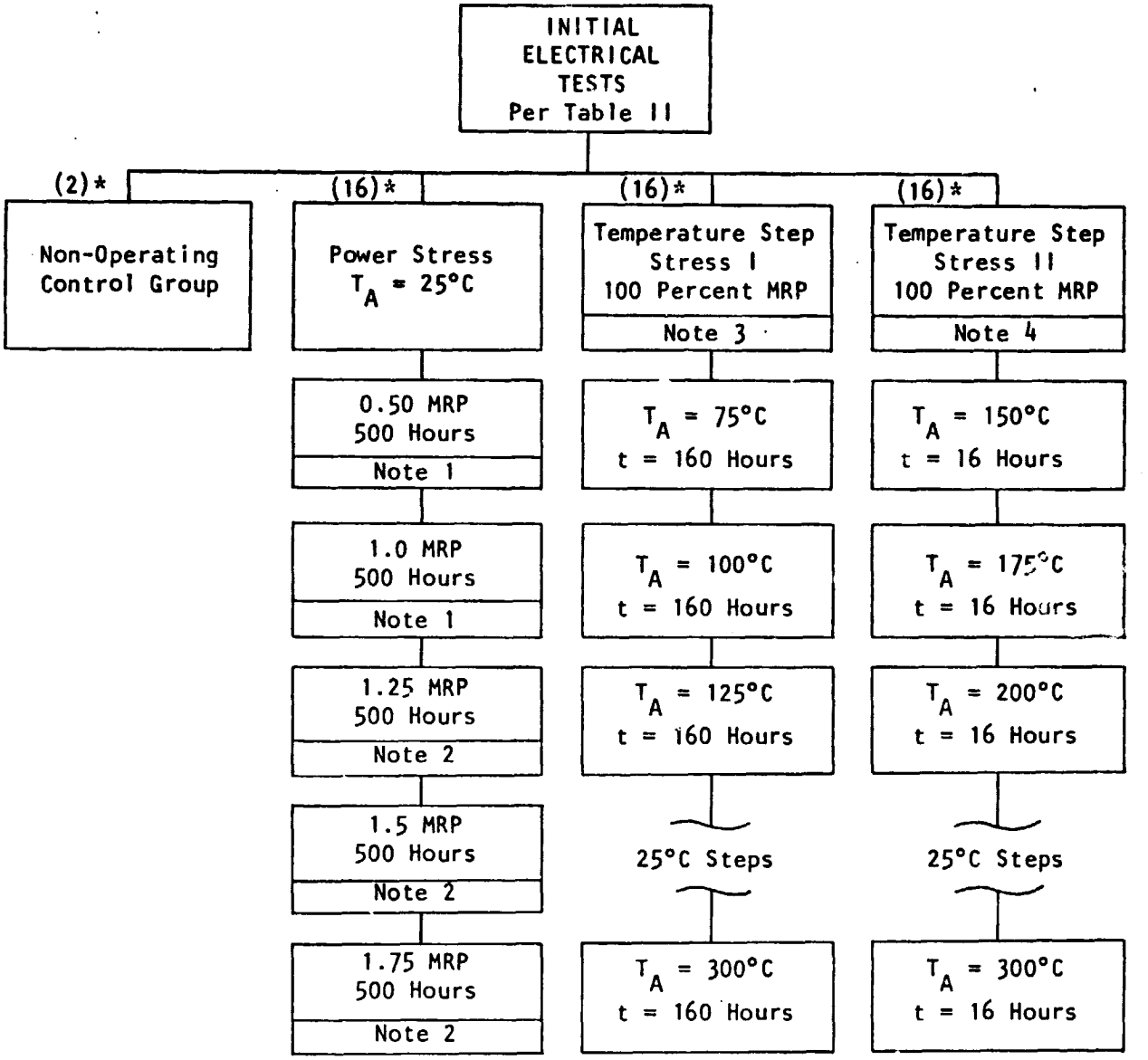


*NOTE

$T_J \approx T_A + 175°C$

FIGURE 5
Time Steps Versus Junction Temperature, Siemens

TABLE I
TEST FLOW DIAGRAM



*Quantity per manufacturer (Texas Instruments and Siemens)

NOTES:

1) Electrical measurements per Table II were made at 50, 150, 250 and 500 hours.
2) Electrical measurements per Table II were made at 10, 25, 50, 150, 250 and 500 hours.
3) Electrical measurements per Table II were made at the end of each 160 hours.
4) Electrical measurements per Table II were made at the end of each 16 hours.

TABLE II
PARAMETERS AND TEST CONDITIONS

PARAMETER	CONDITIONS	SPEC. LIMIT		CAT. LIMIT [1]		UNITS
		MIN	MAX	MIN	MAX	
I_R	@ V_R = 9.0V	—	1.0	—	100.0	µA
B_V	@ I_Z = 20.0mA	11.4	12.6	5.7	18.9	V

NOTES:
1) In addition, any open or short shall be considered catastrophic.

TABLE III
POWER STRESS BURN-IN CONDITIONS

V_Z = 12V	
I_F	Percent P_D
16.6mA	50
33.3mA	100
41.6mA	125
50.0mA	150
58.3mA	175

TABLE IV
GROUP I – POWER STRESS DATA SUMMARY

PARAMETER	I_R = 1μA (max)		B_V = 11.4V (min) 12.6V (max)					
CONDITIONS AND LIMIT	V_R = 9.0V		I_Z = 20mA					
IDENTIFICATION	TI	SIE	TI	SIE				
INITIAL DATA								
MIN VALUE	6.06nA	0.00nA	11.82V	11.88V				
MAX VALUE	211.0nA	29.30nA	12.67V	12.53V				
MEAN	46.35nA	2.361nA	12.20V	12.26V				
STD DEV	56.43nA	7.055nA	1.2125V	0.2049V				
INTERIM DATA								
POWER 50 TO 125% Δ MEAN VALUE								
50% POWER								
50 hrs	21.35nA	0.471nA	0.00mV	10.0mV				
150 hrs	46.95nA	2.263nA	0.00mV	10.0mV				
250 hrs	7.92nA	3.056nA	0.00mV	20.0mV				
500 hrs	2.07nA	2.380nA	- 10.0mV	20.0mV				
100% POWER								
550 hrs	100.45nA	* 624.4μA	-40.0mV	10.0mV				
650 hrs	322.75nA	0.207nA	- 40.0mV	40.0mV				
750 hrs	1.65μA	-0.222nA	- 30.0mV	10.0mV				
1000 hrs	149.75nA	0.319nA	- 30.0mV	20.0mV				
125% POWER								
1010 hrs	114.25nA	0.024nA	-30.0mV	10.0mV				
1025 hrs	115.35nA	0.038nA	-60.0mV	10.0mV				
1050 hrs	141.55nA	0.874nA	-60.0mV	0.00mV				
1150 hrs	1.77μA	-0.697nA	-50.0mV	10.0mV				
1250 hrs	1.11μA	-0.462nA	-70.0mV	20.0mV				
1500 hrs	342.45nA	0.097nA	-60.0mV	20.0mV				

(continued on second sheet)

TABLE IV (Cont'd)

(continued from first sheet) GROUP I — POWER STRESS DATA SUMMARY

PARAMETER	I_R = 1µA (max)		B_V = 11.4 (min) 12.6V (max)					
CONDITIONS AND LIMITS	V_R = 9.0V		I_Z = 20mA					
IDENTIFICATION	TI	SIE	TI	SIE				
INITIAL DATA								
MIN VALUE	6.06nA	0.00nA	11.82V	11.88V				
MAX VALUE	211.0nA	29.30nA	12.67V	12.53V				
MEAN	46.35nA	2.361nA	12.20V	12.26V				
STD DEV	56.43nA	7.055nA	0.2125V	0.2049V				
INTERIM DATA								
POWER 150 TO 175% Δ MEAN VALUE								
150% POWER								
1510 hrs	388.25nA	-0.598nA	-60.0mV	*-440.0mV				
1525 hrs	459.15nA	-0.726nA	-70.0mV	60.0mV				
1550 hrs	604.65nA	-0.640nA	-70.0mV	60.0mV				
1650 hrs	204.35nA	-0.451nA	-70.0mV	70.0mV				
1750 hrs	406.35nA	-0.433nA	130.0mV	70.0mV				
2000 hrs	490.05nA	-0.337nA	20.0mV	-40.0mV				
175% POWER								
2010 hrs	525.95nA	-0.348nA	-70.0mV	90.0mV				
2025 hrs	520.95nA	-0.543nA	-60.0mV	10.0mV				
2050 hrs	578.95nA	-0.503nA	-70.0mV	60.0mV				
2150 hrs	1.58µA	-0.108nA	-60.0mV	90.0mV				
2250 hrs	2.07µA	-0.149nA	-70.0mV	90.0mV				
2500 hrs	6.30µA	*258.6µA	-70.0mV	30.0mV				
FINAL DATA								
MIN VALUE	5.48nA	-0.010nA	11.78V	11.03V				
MAX VALUE	96.10µA	3.620mA	12.45V	12.88V				
MEAN	6.344µA	258.6µA	12.13V	12.29V				
STD DEV	23.20µA	932.3µA	0.2062V	0.4034V				

NOTE: *Catastrophic Rejects removed from data.

TABLE V

GROUP II – TEMPERATURE STRESS DATA SUMMARY

(160 Hour)

PARAMETERS	I_R = 1.0 A (max)		B_V = 11.4V (min) 12.6V (max)	
CONDITIONS AND LIMITS	V_R = 9.0V		I_Z = 20.0mA	
IDENTIFICATION	TI	SIE	TI	SIE
INITIAL DATA				
MIN VALUE	9.76nA	0.040nA	11.85V	11.88V
MAX VALUE	104.0nA	120.0nA	12.57V	12.51V
MEAN	33.5nA	8.17nA	12.22V	12.23V
STD DEV	27.73nA	28.90nA	0.2187V	0.1539V
INTERIM DATA (INITIAL TO FINAL)				
Δ MEAN VALUE				
Total Hrs / Temp (T_A)				
160 / + 75°C	54.93nA	-2.14nA	-30.0mV	30.0mV
320 / + 100°C	54.93nA	-2.14nA	-50.0mV	-0.00mV
480 / + 125°C	1.46 A	-7.42nA	-40.0mV	10.0mV
640 / + 150°C	25.47nA	-6.83nA	-80.0mV	-10.0mV
800 / + 175°C	21.72nA	1.08 A	-50.0mV	- 0.00mV
960 / + 200°C	37.74nA	* 768.5 A	-90.0mV	-10.0mV
1120 / + 225°C	36.52nA	* 1.67mA	-80.0mV	10.0mV
1280 / + 250°C	* 9.91 A	* 3.08mA	-90.0mV	20.0mV
1440 / + 275°C	* 2.02mA	JOB STOPPED	-80.0mV	JOB STOPPED
1600 / + 300°C	* 1.942mA	↓ ↓	*- 870.0mV	↓ ↓
FINAL DATA				
FINAL TEMP (T_A)	+ 300°C	+250°C	+300°C	+250°C
MIN VALUE	0.00nA	0.040nA	5.5V	11.88V
MAX VALUE	9.99mA	9.99mA	20.0V	12.54V
MEAN	1.942mA	3.08mA	11.35V	12.25V
STD DEV	3.796mA	4.53mA	3.693V	0.2157V

* CATASTROPHIC REJECTS REMOVED FROM DATA

TABLE VI
GROUP III – TEMPERATURE STRESS DATA SUMMARY
(16 HOUR)

PARAMETERS	I_R = 1.0μA (max)		B_V = 11.4V(min) 12.6V (max)	
CONDITIONS AND LIMITS	V_R = 9.0V		I_Z = 20.0mA	
IDENTIFICATION	TI	SIE	TI	SIE
INITIAL DATA				
MIN VALUE	6.17nA	0.0nA	11.90V	11.87V
MAX VALUE	396.0nA	18.0nA	12.66V	12.54V
MEAN	94.62nA	1.767nA	12.21V	12.31V
STD DEV	132.2nA	4.38nA	0.2156V	0.1918V
INTERIM DATA (INITIAL TO FINAL)				
Δ MEAN VALUE				
Total Hrs / Temp(T_A)				
16 / +150°C	* 8.61ΩA	0.609nA	0.0mV	10.0mV
32 / +175°C	567.2nA	0.460nA	- 10.0mV	- 20.0mV
48 / +200°C	639.8nA	1.18nA	- 50.0mV	- 40.0mV
64 / +225°C	- 2.47nA	* 6.24μA	- 60.0mV	10.0mV
80 / +250°C	- 16.57nA	* 13.32μA	- 70.0mV	- 760.0mV
96 / +275°C	45.48nA	* 4.79μA	- 70.0mV	- 970.0mV
112 / +300°C	- 7.77nA	* 16.65μA	- 60.0mV	- 970.0mV
FINAL DATA				
FINAL TEMP (T_A)	+ 300°C	+ 300°C	+ 300°C	+ 300°C
MIN VALUE	7.33nA	1.02nA	11.84V	0.1160V
MAX VALUE	505.0nA	99.9μA	12.62V	12.48V
MEAN	86.85nA	16.65μA	12.15V	11.34V
STD DEV	144.4nA	37.23μA	0.2110V	3.245V

* CATASTROPHIC REJECTS REMOVED FROM DATA

TABLE VII
FINAL DATA SUMMARY

PARAMETER	SPECIFICATIONS LIMIT		UNITS	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE					
					POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II	
	MIN	MAX			T.I.	SIEMENS	T.I.	SIEMENS	T.I.	SIEMENS
I_R	-	1.0	μA		+.77013	* +33.962	* +337.36	* +689.95	* +1.4037	* +5.8575
BV	11.4	12.6	V		-.03846	* -.00923	* -.14600	* -.00500	-.04571	-.39143

NOTE: *Catastrophic reject(s) removed from data.

TABLE VIII STEP STRESS CATASTROPHIC FAILURE SUMMARY JAN TX1N759A

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	0	-	1	A
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
125% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
150% 10 hr.	0	-	1	B
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
175% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	1	A

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	-	0	-
100° C	0	-	0	-
125 °C	0	-	0	-
150 °C	0	-	0	-
175 °C	0	-	0	-
200 °C	0	-	3 / 1	A / C
225 °C	0	-	2	A
250 °C	1	A	5	A
275 °C	4	A	JOB STOPPED	
300 °C	7 / 1	A / C		

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150 °C	1 / 1		0	-
175 °C	0	-	0	-
200 °C	0	-	0	-
225 °C	0	-	1	A
250 °C	0	-	2	A
275 °C	0	-	1	A
300 °C	0	-	2	A

MFR A - TI

MFR B - SIE

NOTES:

(A) I_R > 100μA

(B) B_V < 5.7V

(C) B_V > 18.9V

(D) Open

(E) Short

TABLE IX STEP STRESS PARAMETRIC FAILURE SUMMARY JAN TX1N759A

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	1	A		-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	0	-	0	-
100 hr.	1	B		-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
125% 10 hr.	0	-	0	
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
150% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
175% 10 hr.	0	-	0	-
15 hr.	0	-	1	A
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	1 / 1	A / C

GROUP II 160 I TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	-	0	-
100° C	0	-	0	-
125°C	1	B	0	-
150°C	0	-	0	-
175°C	0	-	1	B
200°C	0	-	0	-
225°C	0	-	0	-
250°C	0	-	1	B
275°C	1	A	JOB STOPPED	
300°C	1	B		

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	2	B	0	-
175°C	0	-	0	-
200°C	0	-	0	-
225°C	0	-	0	-
250°C	0	-	0	-
275°C	0	-	0	-
300°C	0	-	0	-

MFR A - TI

MFR B - SIE

NOTES:

(A) B_V Maximum Limit Failure

(B) I_R Limit Failure

(C) B_V Minimum Limit Failure

FAILURE

ANALYSIS

APPENDIX A

POWER STRESS

MSFC STEP-STRESS TEST

FAILURE ANALYSIS- DIODES

JANTX1N759A

Date 26 September 1978

J/N: 2CN242-29A P/N: 1N759A MFR: Siemens

FAILURE VERIFICATION:

S/N	PIV -volts- @ I_Z = 20mA	I_r @ 9.0 V.dc	V_f @ ____ dc	INITIAL REJ.@ Seq.#:	INITIAL REJ. FOR:
9064	11.2 R	6.8 mA		MP-6	I_R
9071	10.6	5.5 mA		MP-27	I_R, PIV
9075	5.0	48 mA		MP-16	PIV
	Limits:	Limit:			
	5.7-18.9 V	500uA Max.			

INTERNAL VISUAL INSPECTION:

All three Siemens diodes have off-center dice, particularly S/N 9071. (See Figure A-1.) No other visual defects were observed which might be significant to the present failures.

CONCLUSIONS:

All three samples have damaged junctions resulting from the power stress to which they were subjected. The exact stress at which this occurs is mainly a function of the junction size, the amount of heat sinking of the die, and the crystal perfection.

S= soft D = drift Inv = inversion Uns = unstable R = resistive

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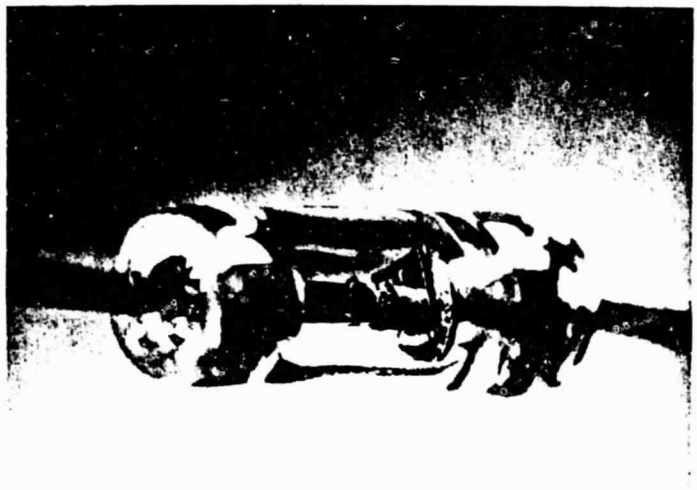

FIGURE A-1
S/N 9071. Magnification 10X.
Typical Siemens diode construction.
Note off-center die.

APPENDIX B

TEMPERATURE STRESS
160-HOUR INCREMENTS

MSFC STEP-STRESS TEST

FAILURE ANALYSIS- DIODES

JANTX1N759A

Date 27 September 1978

J/N: 2CN242-29B P/N: 1N759A MFR: Siemens

FAILURE VERIFICATION:

S/N	PIV -volts- @I_Z = 20mA	I_r @ 9.0 V.dc	V_f @ ____ dc	INITIAL REJ.@ Seq.#:	INITIAL REJ. FOR:
9077	short	short		MP-7	PIV
9084	1.0	> 100uA		MP-9	PIV, I_R
9087	short	> 100uA		MP-9	PIV, I_R
	Limits:	Limit:			
	5.7 - 18.9	500uA Max.			

INTERNAL VISUAL INSPECTION:

The bonding metal between the internal wire lead and the die on some of the Siemens parts shows evidence of overheating and de-wetting. The dice overhang their mountings on all the parts, including those not analyzed. (See Figures B-1 and B-2.)

CONCLUSIONS:

These Siemens diodes failed due to catastrophic junction damage induced by excessive die temperature while under power. Since the bonding metal has been kept above its melting temperature for many hours, it is almost certain that the actual failure mode involved micro-alloying of the bonding metal across the semiconductor junction.

S= soft D = drift Inv = inversion Uns = unstable R = resistive

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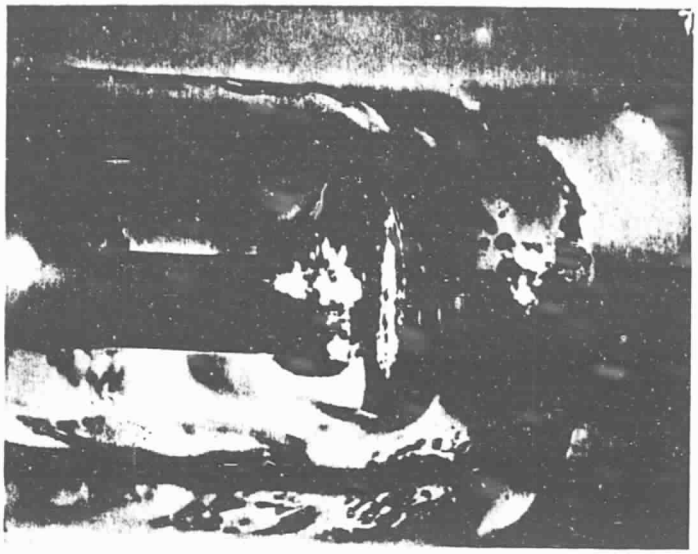

FIGURE B-1
S/N 9077. Magnification 24X
Normal anode to die connection of Siemens sample.

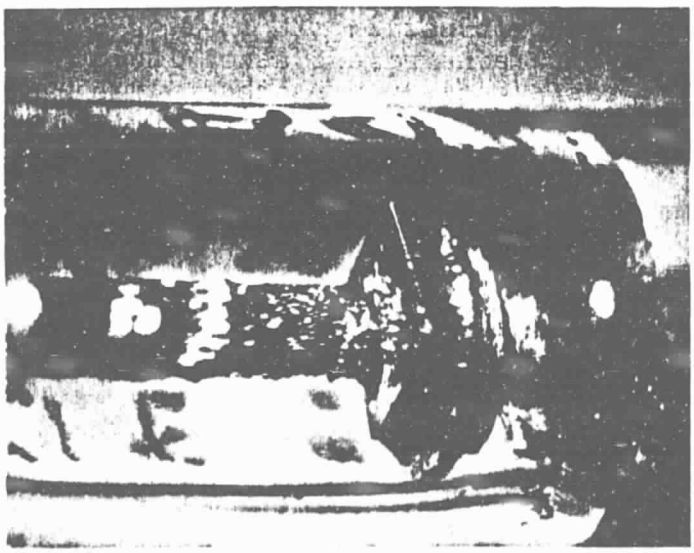

FIGURE B-2
S/N 9084. Magnification 24X.
Anode to die connection disturbed by over-heating. Compare with Figure B-1 above.

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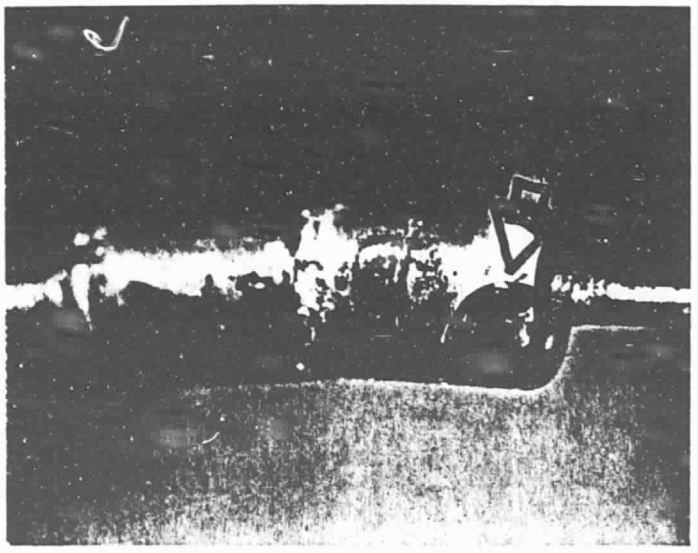

FIGURE B-3
S/N 9146. Magnification 10X.
Typical Texas Instruments sample.
Arrow indicates cracked glass.

MSFC STEP-STRESS TEST

FAILURE ANALYSIS- DIODES

JANTX1N759A

Date 28 September 1978

J/N: 2CN242-29B P/N: 1N759A MFR: Texas Instruments

FAILURE VERIFICATION:

S/N	PIV -volts- @ I_Z = 20mA	I_r @ 9.0 V.dc	V_f @ ____ dc	INITIAL REJ.@ Seq.#:	INITIAL REJ. FOR:
9137	0.5 S	60 uA		MP-11	I_R, PIV
9146	0.5	100 uA		MP-10	PIV
	Limits:	Limit:			
	5.7-18.9V	500uA Max.			

INTERNAL VISUAL INSPECTION:

Both samples have cracked glass. The cracks do not extend to the die cavity. The construction of the failed samples is not accurately in-line. A cross-sectioned view shows the die of S/N 9146 to be cracked. (See Figures B-4 and B-5.)

CONCLUSIONS:

These Texas Instruments samples failed due to catastrophic junction damage. While many of the samples survived the thermal stress procedure without apparent damage, the cross-section of S/N 9146 indicates that this failure was caused by a cracked die. The partially unsupported die mounting and the angular thrust of the anode contact slug evidently acted together to crack the die during the heating of the parts.

S= soft D = drift Inv = inversion Uns =unstable R = resistive

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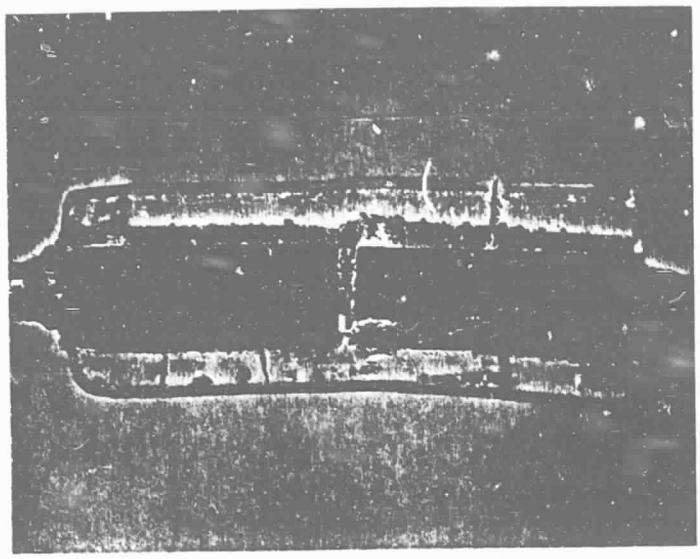

FIGURE B-4
S/N 9146. Magnification 12X.
Cross-sectional view, showing cracked glass, cracked die, and tilted construction.

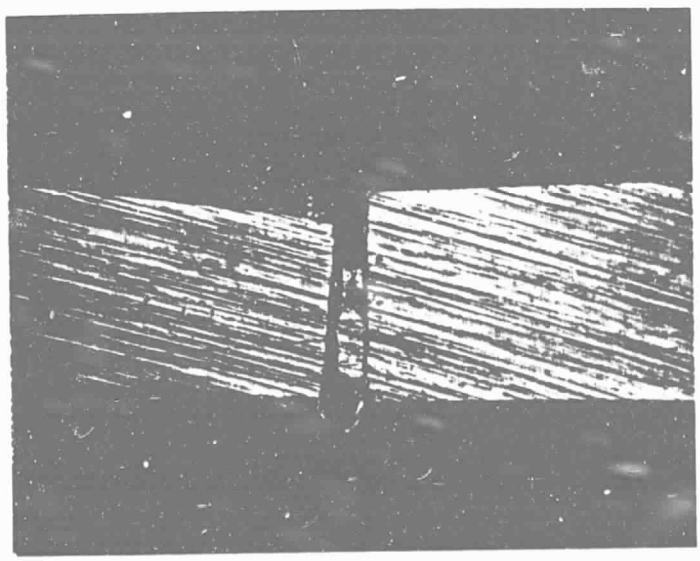

FIGURE B-5
S/N 9146. Magnification 30X.
Cross-section of die cavity area showing cracked die and tilted construction.